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ABSTRACT

Two experiments investigated the impact of immediate knowledge of a correct response (KCR) upon learning in programed instruction. The 356 subjects completed a programed lesson on myocardial infarction taught by means of the PLATO IV computer assisted instructional system. Subjects who received KCR after responding learned significantly more than those who received no KCR or who could peek at the correct answer before responding. Neither a correction procedure, two versions of a time out procedure, nor a forced return procedure improved upon the procedure of KCR after responses. KCR after wrong answers only was slightly better than KCR after right answers only. Reviews of frames relating to incorrect answers failed to improve performance on either an immediate or a delayed criterion test. (Author/PB)

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Feedback Procedures in Programed Instruction

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One of the cardinal principles of programed instruction is that immediate knowledge of the correct response (KCR) facilitates learning. Consequently, programers were unpleasantly surprised when study after study showed that programs teach as well when the KCR after each frame is omitted (Moore & Smith, 1961; Krumboltz & Weisman, 1962; Feldhusen & Birt, 1962; Hough & Revsin, 1963; Moore & Smith, 1964; Rosenstock, Moore, & Smith, 1965; O'Day, Kulhavy, Anderson, & Malznski, in press). Lublin (1965) found that a group that completed the first 1,052 frames of the Holland and Skinner (1961) program without KCR actually did significantly better on the criterion test than the group that saw the correct answer after every frame.

The usual assumption has been that KCR is reinforcing; however, there is good reason to believe that this assumption arises from an inappropriate analogy to the food- or water-deprived animal (cf. Anderson, 1967). Reinforcement maintains in greatest strength the response which immediately precedes it. If an explicit "observing response" (Holland, 1958) were required of students in order for them to receive KCR, the rate at which this observing response occurred would be a measure of the reinforcing value of KCR. Melching (1966) gave KCR only when requested to students completing a 364-frame program on magnetism. Feedback was requested on just 31% of the frames. Errors were made on 28% of the

frames in which KCR was requested but on only 4% of the frames in which KCR was not requested. There are those who contend that when a student bypasses KCR he is engaging in "self-reinforcement" because he "knows he is right;" however, it can be argued that "the only decent thing to do in the face of these data is to question the assumption that KCR is a reinforcer. After all, the food-deprived pigeon does not ignore the pellet of food even when it 'knows food is available'--that is, when there is a reliable discriminative stimulus for the presence of food, such as the sound of the food magazine" (Anderson, 1967, pp. 149-150).

If KCR is a reinforcer then, by analogy with the animal literature, introducing a delay between the response and KCR should interfere with learning. No such interference appears. Indeed, a number of investigators have found that a delay between the response and KCR not only fails to impede learning but actually improves retention (e.g. Sassenrath & Yonge, 1969).

Several experiments employing self-instructional programs have presented KCR on intermittent schedules (Krumboltz & Weisman, 1962; Lublin, 1965; Rosenstock, Moore, & Smith, 1965). The investigators were apparently aiming to produce the well-known effects of intermittent reinforcement, persistence and resistence to extinction. The difficulty is that in programed lessons the responses and the stimuli are continually changing and under these conditions intermittent reinforcement impedes learning. So, even if KCR is reinforcing, it is unclear what effect an intermittent schedule should have.

It is obvious that KCR can provide corrective feedback when the student makes a mistake. Buss and his associates (e.g. Buss, Braden, Orgel, & Buss, 1956) have found that either "right" and "wrong" or no comment and "wrong" produced more rapid learning than saying "right" when the subject was correct and giving no comment when he was wrong. Travers, Van Wagenen, Haygood, & McCormick (1965) found no difference between saying "right" and giving no comment when the student was correct. When the student was incorrect, however, there was a big advantage to giving him the correct response in addition to telling him that he was wrong. These studies suggest that KCR functions more as corrective feedback than as reinforcement.

One of the purposes of the research described herein was to explore the function of KCR in programed lessons. If KCR is chiefly important as reinforcement then the optimum procedure would be to differentially reinforce correct responses, that is, to present KCR after correct answers and withhold KCR after incorrect answers. On the other hand, if the main function of KCR is to provide corrective feedback, then presenting KCR after incorrect responses only should be as effective as furnishing KCR after every response.

Whatever the exact function of KCR, several lines of reasoning, as well as a great deal of empirical evidence from studies that have not involved programed instruction, suggest that KCR should be facilitative. A plausible interpretation of the failure to find facilitation in programed lessons is that students pay less attention when immediate KCR

is provided. Sometimes there may be a gross-circuiting of attention when the correct answer is readily available: the student may copy it into the blank without reading the material in the frame. At least two of the previous studies employed programed texts in which the frames were printed in consecutive order down sheets of paper (Lublin, 1965; Rosenstock, Moore, & Smith, 1965). The correct answers appeared immediately below the frames. This arrangement makes accidental exposure of the answers difficult to avoid, and of course makes deliberate cheating easy. It is known that students do not learn much simply from copying answers into blanks (cf. Anderson & Faust, 1967). Both of the experiments reported in this paper were completed using a computer-controlled system which made it possible to insure that KCR was not available until after the student responded. In addition, the second experiment directly investigated the hypothesis that many students turn a program into a sequence of "copying frames" when they have access to KCR before responding.

Elsewhere we have argued that students tend to follow the law of least effort, especially when they are tired, bored, or under pressure to work quickly (Anderson, 1970). In other words, it is argued that students will often fail to learn what a lesson is intended to teach them when it is possible to short-circuit the instructional task. Even if they are not actually copying from the KCR, students may study less carefully when KCR is always immediately available. There is some indirect evidence to support this proposition. Lublin (1965) found that the group that always received KCR completed the program in substantially less time

than the other groups. Similarly, Sullivan, Baker, & Schutz (1967) found that a group which received KCR on tests inserted within a 60-page text on military justice performed no better on the criterion test than a group that did not receive KCR, but finished the text in less time. Sullivan, et al (1967, pp. 167-168) interpreted their results to mean that "'no feedback' Ss expended more time and effort attempting to learn from the prose textual material. For these individuals, of course, this [was] the only instructional material in the text. The 'feedback' Ss, on the other hand apparently neglected the text material to some degree and used the instructional value of the immediate feedback..." If students become careless because of KCR, this could offset KCR's presumed beneficial effects. It is possible, therefore, that KCR would show to advantage if procedures were employed which maintained attention. Two such procedures were investigated in the present research. The first was a brief "time out" following errors. A delay is mildly aversive and may increase the incentive for careful attention to the material (cf. Zimmerman & Ferster, 1963). Based on the same reasoning, a correction procedure was also investigated. Under this procedure, the student had to respond correctly to each frame, making up to ten responses if necessary, before he advanced to the next frame.

Experiment I

Method

Design and subjects. The experiment involved eight feedback procedures and three levels of verbal ability. The Ss were 168 summer students

enrolled in an educational psychology course. Participation in the study was a course requirement. Prior to the experimental sessions all of the potential Ss were given the ETS Wide Range Vocabulary Test (French, Ekstrom, & Price, 1963). On the basis of scores on this test, Ss were stratified into three levels of verbal ability. The Ss within each level were randomly assigned to feedback procedures. Ten Ss were replaced for failure to complete the program within two hours. Eighteen additional Ss participated in a pilot study.

Materials. The program was Tobias' (1968) modification of a linear program (originally prepared by Francis Mechner) on the diagnosis of myocardial infarction from electrocardiagrams. The program was too long to complete within a two hour experimental session so 36 frames from a section on the incidence and causes of heart disease were removed. The form of the program used in the study entailed 112 frames averaging 22 words in length. Many frames also contained diagrams, ECG tracings, or tables. Each frame required the S to respond to either a multiple-choice or completion question. In the version of the program used in this research students were not asked to construct drawings.

The criterion test contained 39 multiple-choice and completion items. Many of the items required multiple answers; hence, the total possible score was 84. Mispelled answers to completion items were counted right as long as the response was recognizable. None of the questions required the S to construct drawings. Some of Tobias' (1968) items were used and the remainder were developed by the authors.

Feedback conditions. KCR was presented separately from either the preceding or following frame. In other words, a frame and KCR were never simultaneously exposed, though the KCR often repeated portions of the preceding frame. The feedback procedures were as follows:

0%-KCR. No KCR was presented after any frame.

100%-KCR. KCR was presented after every frame.

KCR-R. KCR was presented after right answers only.

10%-KCR-R. KCR was presented after a random 10% of correct responses; no KCR was given after incorrect responses.

KCR-W. KCR was presented after wrong answers only.

TO. There was a 15 sec. time out, with the frame in view, after wrong answers; then KCR was presented. No KCR was provided after right answers.

COR. KCR was provided after each right answer. In the event of a wrong answer, the program looped back to the same frame with instructions to try again. The program advanced to KCR whenever an S made 10 errors on the same frame.

VOL. After responding, S voluntarily selected KCR or no KCR. Pressing one button gave KCR; pressing the same button again led to the next frame. Pressing another button caused the next frame to appear immediately.

Procedure. The experiment was conducted on PLATO, a computer-based instructional system located at the University of Illinois (Bitzer, Hicks, Johnson, & Lyman, 1967). PLATO consists of a Control Data Corporation

1604 computer connected to 20 student stations housed in semi-enclosed cubicles. Each station contains a 12 inch square TV screen upon which stimuli are presented and a keyboard upon which responses are entered.

The Ss were run in groups of 10-18. Of course, PLATO allowed individualized treatment of each S. All experimental groups were represented in most sessions. PLATO presented the instructions appropriate for each feedback condition, presented the program, and recorded errors during the program, time on each frame, and time on each KCR presentation. The time data were recorded in 60ths of a second and were probably accurate to one-third of a second. When an S completed the program he was directed to a nearby room where the criterion test was administered in paper-and-pencil form.

Results

Table 1 contains mean correct on the criterion test, mean program errors, mean time per frame and mean time per KCR presentation. There were

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Insert Table 1 about here

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significant differences on the criterion test among feedback procedures, $F(7,144) = 3.37$, $p < .01$, and among verbal ability levels, $F(2,144) = 3.76$, $p < .05$. The interaction between these factors was not significant. Newman-Keuls tests showed that the 100%-KCR, TO, COR, and VOL groups all did significantly better ($\alpha = .05$) on the criterion test than the 0%-KCR group. No other comparisons were significant.

The differences among feedback procedures in mean frequency of program errors (counting only the first error to any frame in the COR group) were not significant, $F(7,144) = 1.93$. Verbal ability was related to program errors, $F(2,144) = 11.82$, $p < .01$. There was also a Feedback Procedure X Ability interaction, $F(14,144) = 2.16$, $p < .05$, primarily because of the relatively high frequency of errors on the part of low ability Ss in groups 0%-KCR, 100%-KCR, and KCR-R.

Program errors were considerably more frequent than expected, due in part to the fact that PLATO was programed to count typographical errors and spelling mistakes. This fact may have undermined the performance of the TO and COR groups since delays or repetition because of trivial mistakes undoubtedly would be annoying. Incidentally, the COR and TO groups spelled correctly 94% of the technical terms on the criterion test whereas the average for the other groups was 85%.

There were no significant differences, $F(7,144) = 1.98$, among the feedback procedures in mean time per frame (including only the first exposure times in group COR). Time per frame was a decreasing function of verbal ability, $F(2,144) = 6.11$, $p < .01$. There were significant differences, $F(6,126) = 13.79$, $p < .01$, among the feedback procedures in mean time per KCR exposure, excluding the 15 sec. time out in group TO. Newman-Keuls tests showed that the TO group spent significantly more time ($\alpha = .05$) per KCR than all groups except KCR-W and VOL. Groups KCR-W and VOL spent more time than KCR-R, COR, and 100%-KCR. Group KCR-W also spent more time than 10%-KCR-R. No other comparisons were significant.

Experiment 2

The chief purpose of Experiment 2 was to replicate, if possible, the finding of Experiment 1 that students who get KCR learn more than students who do not, and to test the hypothesis that KCR is facilitative only when students cannot peek at it before responding. Also investigated were the effects of delayed review of frames upon which errors were made, and two procedures intended to maintain attention by punishing students for errors.

Method

Design and subjects. The experiment entailed an uninstructed control group, six feedback procedures, and three levels of verbal ability. The Ss, who were randomly assigned to procedures from within ability levels, were 188 students enrolled in an introductory educational psychology course. Two additional Ss were dropped for failure to complete the program within two hours and the 19 Ss in one session were lost when the treatment was not implemented properly because of modifications which had been made in the systems program.

Materials. Based in part on the data from Experiment 1, a physician and an experienced programer modified both the program and the criterion test. Nineteen frames in the program were consolidated or deleted. Eighteen frames were revised slightly. Five new frames were added. The version of the myocardial infarction program used in Experiment 2 consisted of 98 frames averaging 23 words in length and requiring a total of 126 separate responses. Forty-five frames included drawings as well as text.

The criterion test was modified on the basis of an item analysis and judgements about validity. Twelve items were deleted and nine new items constructed by the authors were added. The final test contained 36 multiple-choice and completion questions yielding a possible score of 66.

Feedback conditions. KCR appeared in the lower righthand corner of each frame below three rows of Xs, rather than on a separate slide as in the initial study. Both the frame text and the KCR were in view when KCR was presented. The feedback procedures are described below.

0%-KCR. Same as Experiment 1.

100%-KCR. Same as Experiment 1.

FOR. KCR was presented immediately after the response to each frame. Following KCR on error frames, the S was forced to repeat the frame until he responded correctly.

REV. KCR was presented immediately after the response to each frame. Frames upon which errors were made were repeated after sections 28, 24, 19, and 27 frames in length. Frames still in error were then presented again. Review continued until each frame had been answered correctly, at which point the next section began.

TO_2. KCR was presented after every frame. There was a 15 sec. time out, with the frame text and KCR in view, whenever an error occurred.

PEEK. KCR was presented at the same time the frame was exposed. In other words, S had access to KCR before he responded. Initial instructions repeatedly stressed that S should respond before he looked at the KCR.

CON. This was an uninstructed control which received only the criterion test.

Procedure. In order to reduce the number of unimportant program errors, PLATO was programed to count common mispellings of technical terms as acceptable responses. To obtain an estimate of retention, the criterion test was re-administered 14-16 weeks after the experimental sessions to those Ss still available. The procedure of the two experiments was identical in all other respects.

Results

Table 2 contains mean correct on the criterion test, mean program errors, mean time per frame, and mean time per KCR presentation for the groups in Experiment 2. An unweighted means analysis of criterion test

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Insert Table 2 about here

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variance, which did not include the uninstructed control group, revealed significant differences among feedback procedures, $F(5,128) = 3.30$, $p < .01$, and ability levels, $F(2,128) = 4.99$, $p < .01$. As predicted, the 100%-KCR group learned more than either the 0%-KCR, t(approx. 46) = 2.16, $p < .05$, or PEEK group, t(approx. 46) = 3.83, $p < .01$. Newman-Keuls tests showed no further significant ($\alpha = .05$) differences.

Analysis of program errors yielded significant effects for both feedback procedures, $F(5,128) = 9.18$, $p < .01$, and ability level, $F(2,128) = 14.19$, $p < .01$; however, unlike the first experiment, the interaction of these two factors was not significant. Newman-Keuls tests showed that the frequency of program errors was significantly lower ($\alpha = .05$) in the PEEK condition than in any other. None of the remaining comparisons was significant.

Ignoring FOR Ss, on whom data was not collected, and including only the first exposure of frames in group REV, analysis of time per frame showed significant effects for feedback procedure, $F(4,106) = 5.15$, $p < .01$, and verbal ability, $F(2,106) = 5.33$, $p < .01$. Newman-Keuls tests showed that the 0%-KCR group spent significantly more time per frame than the other groups. No other comparisons were significant.

An analysis of time per KCR exposure showed no significant effect due to feedback procedure or ability.

There were no differences among feedback procedures on the delayed criterion test; however, all the groups that had received the program performed significantly better than the uninstructed control group.

Discussion

The most important result of the experiments described in this paper was the finding that students who received KCR after every frame performed better on the criterion test than students who received no KCR. To our knowledge, only one other experiment has ever found that KCR facilitates learning from a programed lesson (Meyer, 1960). In many of the previous studies it was possible for the student to copy the correct answer into the blank without studying the frame. This, we believe, was a major reason for poor results using KCR. The present experiments were completed on a computer-controlled instructional system which made it possible to insure that the student composed a response before he saw KCR.

The hypothesis is that many students will turn a program into a series of "copying frames" when it is possible for them to see KCR before responding. This hypothesis was directly investigated in Experiment 2. Despite the

fact that the instructions for the PEEK condition stated three times that the student should enter his answer before he looked at the correct answer, the PEEK group learned substantially less than the 100%-KCR group, indeed, even less than the 0%-KCR group. The PEEK group averaged about half as many program errors as the other groups. Merely receiving KCR did not reduce errors since errors were almost as frequent in the 100%-KCR group as they were in the 0%-KCR group. Therefore, the very low frequency of errors in the PEEK group must have been due to copying. After the experiment students were asked to make any comment they wished about the program. Eleven of the 22 Ss in the PEEK group mentioned looking at the KCR before responding. Sample comments: 1) "It's hard not to look at the answers. It would be better if they were given in the next frame." 2) "The answers should not be shown immediately, as this causes cheating to be easier." 3) "I enjoyed it. One problem, however, I could not help seeing some of the answers out of the corner of my eye, even though I tried not to look." 4) "Very interesting, but I tend to look at the answers too soon."

It may be questioned whether the results obtained under the PEEK condition are generalizable to program formats in which KCR is less prominently displayed. Programed texts printed in the "down the page" format are probably quite susceptible to copying. Even when a mask is provided to cover the answers, the student may not use the mask, he may inadvertently expose the KCR too soon, or, of course, he may cheat. The student must turn the page to find KCR when studying a programed text

arranged in the "across the page" format. This arrangement precludes accidental exposure of KCR but it does not prevent cheating. Premature exposure of KCR is probably not uncommon in programed texts no matter what the format. Anderson (1969) evaluated the effectiveness of a programed text on population genetics in fifteen high school biology classrooms. To avoid accidental exposure of KCR, each frame occupied a separate page; the KCR for that frame appeared at the top of the next page. For the same reason, the program was mimeographed on blue paper through which the KCR could not be read (cf. Brown, 1966; Anderson, Faust, & Roderick, 1968). When they completed the program students were asked how frequently they had turned the page and copied the correct answer when they found a question difficult. Despite the fact that the directions to the program exhorted students to "write an answer to each question and fill in each blank before you look ahead to the correct answer," better than 40% of the students said they sometimes copied answers to difficult questions and 20% said they usually did. Achievement was a decreasing function of reported frequency of copying.

Insuring that the student responds before KCR is provided will prevent him from turning a program into a series of copying frames, but such control will not help if the program already consists largely of copying frames. Fig. 1 contains three sample frames from a program on how to

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Insert Fig. 1 about here

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program. It could not possibly make any difference whether KCR were furnished after either of the first two frames, because the frames themselves contain the answers. KCR would also be irrelevant after the third frame if it appeared immediately after the other two frames, since these frames comprise a strong "sequence prompt." Several studies using teaching machines have failed to show a significant advantage for KCR, despite the fact that the machine presumably prevented the student from seeing KCR before he responded (Moore & Smith, 1961; Feldhusen & Birt, 1962; Hough & Revsin, 1963; and Moore & Smith, 1964). Our best guess is that KCR failed to show to advantage because the programs used in these studies contained many copying frames and were otherwise heavily-prompted.

One of the purposes of Experiment 1 was to investigate whether KCR functions as reinforcement or corrective feedback. For what it is worth the KCR-W group performed somewhat better on the criterion test than group KCR-R; however, the difference was not significant. Neither the KCR-W nor KCR-R group was significantly different from the 0%-KCR or 100%-KCR groups.

Two kinds of time out procedure, a correction procedure, and a forced return procedure were investigated under the assumption that mild punishment for errors would cause Ss to be more careful. None of these procedures improved upon 100%-KCR.

The VOL condition was included in Experiment 1 in order to try to replicate Melching's (1966) finding that Ss choose KCR on only a small

proportion of frames. Our Ss selected KCR on 95% of the frames. To advance to the next frame, an S could either press the KCR button twice in rapid succession or press an alternative button once to advance directly. We suspect that most Ss used the former strategy, which would explain the difference between our results and Melching's.

Holland and Porter (1961) reported that delayed review of frames upon which errors were made improved retention when the criterion test was readministered after six months. The present research failed to replicate this finding. The REV group performed slightly worse than the 100%-KCR group on both the immediate and delayed criterion test.

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Footnote

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Table 1

Means for Each Feedback Procedure in Experiment 1

Measure	0%-KCR	100%-KCR	KCR-R	10%-KCR-R	KCR-W	TO	COR	VOL
Criterion test correct	57.9	68.7	61.8	61.3	64.5	67.0	68.5	66.2
Program errors	32.8	29.0	34.8	34.7	31.6	25.7	26.0[b]	32.2
Time per frame (sec.)	31.2	29.7	28.6	30.9	29.1	30.4[a]	23.9[b]	28.1
Time per KCR (sec.)	----	4.0	3.3	5.8	8.7	10.2[a]	3.9	7.5

Note:--There were 21 Ss in each group, seven at each ability level.

[a]Does not include 15 sec. penality for wrong answers.

[b]Includes only the first exposure to any frame.

Table 2

Means for Each Feedback Procedure in Experiment 2

Measure	0%-KCR	100%-KCR	FOR	REV	TO_2	PEEK	CON
Number of Ss	26	24	25	25	24	22	42
Criterion test correct	47.4	52.8	49.6	47.5	49.9	43.3	16.4
Program errors	31.2	27.7	28.5[a]	27.9[a]	26.5	14.9	----
Time per frame (sec.)	28.7	24.7	b	22.8[a]	23.5[c]	23.9	----
Time per KCR (sec.)	----	3.2	b	2.7[a]	3.3[c]	----	----

[a]Includes only the first encounter with any frame.

[b]No data collected.

[c]Does not include 15 sec. penality.

S-6. There are a number of assumptions we (the programmers) must make about you (the learner). One is that you read at a certain level and have a vocabulary consistent with this program. Programmers must make _____ about the learner.

R-6. assumptions

S-8. We, as programmers, not only have to make certain assumptions about you, the learner, but we also must determine the goals or objectives of the program. The goals or _____ as well as the assumptions are integral parts of programming for automated instruction.

R-8. objectives

S-13. Two important considerations of "programmed learning" are to make (a) _____ about the learner and to determine the (b) _____ of the program.

R-13. (a) assumptions
(b) objectives

Fig. 1. Three frames from a program on how to program. From Lysaught and Williams (1963, p. 104).

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13. ABSTRACT

356 Ss in two experiments completed a programed lesson on the diagnosis of myocardial infarction. The experiments were conducted using a computer-based instructional system which insured that, unlike many previous studies, the S responded before he received knowledge of the correct response (KCR). Ss who received KCR after they responded learned significantly more than Ss who received no KCR or who could peek at KCR before they responded. Neither two versions of a time out procedure, a correction procedure, nor a forced return procedure improved upon KCR after responses. KCR after wrong answers only was slightly better than KCR after right answers only. Review of incorrect frames failed to improve performance on either an immediate or delayed criterion test.

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